$\gamma = \alpha + j\beta$

تتغير حسب الوسط

$|\hat{E}| = E_0\, e^{-j}\, e^{-}$

attenuation const α

الجماهيرية العربية الليبية الشعبية الاشتراكية العظمى

جامعة الفاتح- كلية الهندسة

قسم الهندسة الكهربية والإلكترونية

الامتحان النصفي2 لمادة الكهرومغناطيسية (EE 313) لفصل الخريف2009/2008

~~أجب~~ على جميع الأسئلة	الزمن:1:30

Q1.

a- What is a uniform plane wave? **(6marks)**

b-A uniform plane wave in empty space (free space) has the electric field, $\hat{\vec{E}}(y) = \boxed{95}\, e^{j0.5y}\,\vec{a}_z$ V/m.

(i)- Determine the frequency and the amplitude of the field? **(6marks)**

(ii)- What is the direction of the travel? **(3marks)**

$\beta = 0.5$ rad/m

(iii)-Find the associated $\hat{\vec{B}}$ field. **(5marks)**

$\beta = \omega\sqrt{\mu_0\varepsilon_0}$

(iv)- Express $\hat{\vec{E}}$ and $\hat{\vec{B}}$ in real time form. **(10marks)**

$\omega = \frac{\beta}{\sqrt{\mu_0\varepsilon_0}} = 2\pi f$

$\vec{E}(y) = 95\cos(2\pi f t + 0$

Q2.

a- Discuss in brief the concept and the causes of the followings:

(i) - Electric polarization in a dielectric material. **(8marks)**

(ii)- Magnetic polarization in a magnetic material. **(8marks)**

b-

(i)- Suppose a $\vec{B}$ field is applied to a cube of magnetic material of 5meters on aside, such that $\vec{M}$ is given by: $\vec{M} = 5y\,\vec{a}_x + 4z\,\vec{a}_y$ A/m. Find the Magnetization current density $\vec{J}_m$ in the material as well as the surface magnetization current density $\vec{J}_{sm}$. Sketch the bound current field $\vec{J}_m$ in the cub. **(14marks)**

(ii)- Given the electric polarization field $\vec{P} =$ [illegible]$y\cos\omega t\,\vec{a}_y$ $\mu C/m^2$. Find the polarization current density $\vec{J}_p$ and the polarization bound charge density ρ_p at the frequency f = 4MHz. **(10marks)**

$-\nabla\cdot P = \rho_p$

Q3-

a- Discuss in brief the Homogeneity, linearity and isotropy in materials. **(6marks)**

b-Two semi-infinite region, air (region1) for z > 0, and dielectric (region2, in which $\varepsilon = 5\varepsilon_0$) for z < 0, are separated by the interface at z = 0. In the air region, the constant electric field $\vec{E}_1 = -5\,\vec{a}_x + 10\,\vec{a}_y + 15\,\vec{a}_z$ V/m is given.

(i)- Find $\vec{D}$ *and* $\vec{E}$ for both regions. **(6marks)**

(ii)- Sketch the $\vec{E}_2$ and $\vec{D}_2$ at the origin. **(6marks)**

(iii) Find the refraction angle θ2 and θ1 from the normal in both region if the normal unit vector $\vec{n}$ is directed from region2 to region1. **(12marks)**

مع تمنياتي للجميع بالتوفيق ....د/ محمد الت...

$\vec{J}_p = \frac{\partial\vec{P}}{\partial t}$ | $\nabla\cdot\vec{P} = \rho_p$

Uni
EE31

Test #2 (1٥.٣٣)

Q1) Fo

الجماهيرية العربية الليبية الشعبية الاشتراكية العظمى
كلية الهندسة - جامعة الفاتح
قسم الهندسة الكهربية والإلكترونية
الامتحان النصفي الثاني لمادة الكهرومغناطيسية (EE 313) لفصل الربيع 2008

امال

الزمن: ساعتان

أجب على جميع الأسئلة

Q1.

a.

(i). Briefly describe the phenomenon of magnetization in a magnetic material. What are the different kinds of magnetic materials?

(ii). What is an electric dipole? How is its strength defined? What are the different kinds of electric polarization?

b. An electric field $\vec{E} = 100\rho \sin\omega t\ \vec{a}_\rho$ V/m is given to exist in a certain region, with a relative dielectric constant $\varepsilon_r = 5$ Find the following fields:

(i) – The electric polarization field $\vec{P}$. (ii). The polarization bound charge density ρ_p.

(iii)- The displacement flux density $\vec{D}$. (iv). The volume bound charge density $\vec{J}_p$.

Q2.

a.

(i). Discuss the concept of the conservation of the electric charge.

(ii). Determine the relaxation expression for the time decay of a charge distribution in a conductor if the initial distribution at $t = 0$ is $\rho_{v0} = 6.C/m^3$. If the conductivity of the conductor $\sigma = 3*10^6$ ℧/m and the permittivity $\varepsilon = 18x10^{-12}$ F/m, find the time constant of the free charge density decay. Sketch ρ_v versus time, t

b. Two semi-infinite region, air (region1) for z > 0, and dielectric (region2, in which $\varepsilon = 8\varepsilon_0$) for z < 0, are separated by the interface at z = 0. In the air region, the constant electric field $\vec{E}_1 = -1\vec{a}_x + 1\vec{a}_y + 5\vec{a}_z$ V/m is given.

(i)- Find $\vec{D}$ *and* $\vec{E}$ for both regions.

(ii)- Sketch the $\vec{E}_2$ at the origin.

(iii) Find the refraction angles θ1 and θ2 from the normal in both regions if the normal unit vector $\vec{n}$ is directed from region2 to region1.

Q3.

Let us consider two infinite parallel, perfectly conducting planes occupying the planes x = 0 and x = d and kept the potential ϕ(x) = 40V at x = d, and ϕ(x) = 0 at x = 0. Solve Laplace's equation in one dimension for the potential function and then find the electric field in the region of interest if the dielectric between the two parallel plane, ε = 3ε0.

Q4.

a.

(i)-Explain what is the skin depth (or penetration depth) for a plane wave propagating in lossy medium.

(ii)- Compute the skin depth for sea water with σ =6. S/m, εr = 80 and μr = 1 (take $\mu_0 = 4\pi \times 10^{-7}$ H/m, $\varepsilon_0 = 8.854 \times 10^{-12}$ F/m) at f = 12GHz.

b. For a plane wave propagating in sea water with $\vec{E}$ field given by,
$\vec{E} = 30e^{\gamma z}\ \vec{a}_x$ V/m.

(i)- what will be the direction of travel? (-Z)

(ii)- Compute α, β, γ and η for the medium.

(iii)- What will be the expression for $\vec{H}$ field associated with $\vec{E}$ field?

(iv)- What will be the magnitude of the $\vec{E}$ field after traveling 7 skin-depth in the sea water?

University of Tripoli **Faculty of Engineering** **EEE Department**
EE313 Test2 **Fall 2016** **Time : 75minutes**

linear 1 compound

Q1) For the uniform plane wave in empty space $\vec{E}(x) = 1000e^{-j\beta_o x}\vec{a}_y$ v/m $+a_x$

a) Determine direction of propagation and type of polarization. [2M] $+a_x$ $a_E \times a_B = a_k$

b) Find the associated $\vec{B}$ ~~field~~ magnetic field [3M] $B = \frac{E \times a_k}{\eta}$ $\boxed{B = 4H}$ a_k

c) Find the phase constant β_o at frequency f =*40MHz*. [1M] $\beta = \omega\sqrt{\epsilon_o \mu_o}$

$\beta = 4H$ $\cos^2\varphi = \frac{1}{2}\varphi$ $\cos\varphi = \frac{1}{2}\varphi$

Q2) Explain the following $\frac{1}{2}$ $\frac{1}{2}\varphi$

a) Wave polarization [1M]

b) Dielectric polarization [1M]

c) Boundary condition for an electromagnetic wave when passing from one region to another. [2M]

$a_n = a_x$

Q3) The half space (region 1) $0 < x$ has $(3\varepsilon_o, 6\mu_o, 0)$, $\vec{E}_1 = 4\vec{a}_x + 3\vec{a}_y - 5\vec{a}_z$, $\vec{H}_1 = 2\vec{a}_x + 8\vec{a}_y + 10\vec{a}_z$ the other half space for (region 2) $0 > x$ has $(4\varepsilon_o, \mu_o, 0)$, Find $\vec{E}_2$ and $\vec{H}_2$ If:

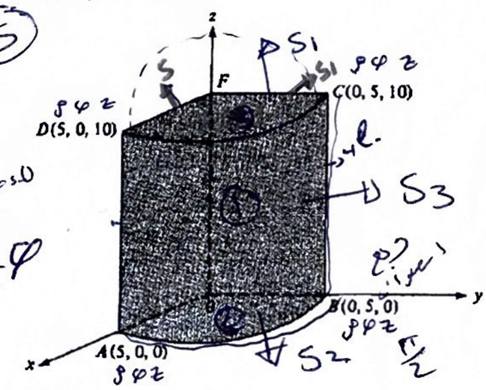
i. At the interface *x=0* the surface current density is zero $\vec{J}_s = 0$ [2.5M]

ii. at the interface *x=0* the surface current density is $\vec{J}_s = 4\vec{a}_y - 8\vec{a}_z$ A/m [2.5M]

Q4) A vector field $\vec{F}(\rho,\phi,z)$ is given by $\vec{F}(\rho,\phi,z) = \rho^2\cos^2\phi\,\vec{a}_\rho + z\sin\phi\,\vec{a}_\phi$ exists in the region shown in Fig.

i. Find the divergence of the vector $\vec{F}(r,\theta,\phi)$ [1M] $\rho\varphi z$ (5)

ii. Illustrate the validity of the divergence theorem[4M]



sin cos
cos − sin

$dv = \rho\, d\rho\, d\varphi\, dz$

$\sin 2\theta = 2\sin\theta\cos\theta$

$\frac{1}{2}\varphi$

$\nabla \cdot F = \frac{1}{\rho}\frac{\partial A_\rho}{\partial \rho} + \frac{\partial \rho A_\phi}{\partial \phi} + \frac{\partial A_z}{\partial z}$

$\frac{1}{\rho}\,\partial \rho A$

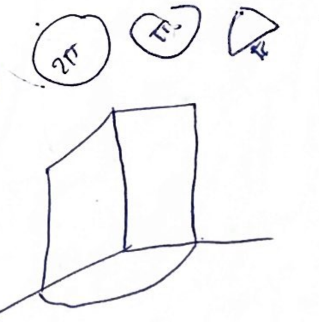
$\rho\, d\rho\, d\varphi\, dz$

$\frac{1}{\rho}$ $\frac{1}{\rho}$

$\cos^2 = \frac{1}{2} + \frac{1}{2}\cos 2\theta$

a_z

2π



$dy\,dz\,a_x$ $\rho\, d\rho$

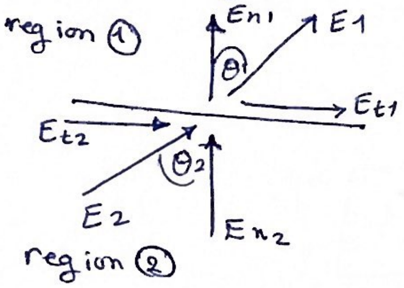
$\rho\Big|_0^5 \ \varphi\Big|_0^5 \ z\Big|_0^{10}$

$\rho = \sqrt{x^2+y^2} = 25+0$

$dv = \rho\, d\rho\, d\varphi\, dz$

sin cos
cos − sin

* Boundary Condition:-



$\boxed{\bullet \text{ Electric field}}$ $\quad \bar{E} = E_t \bar{a}_t + E_n \bar{a}_n$

$$\left.\begin{aligned} E_{t1} &= E_{t2} \\ \frac{D_{t1}}{\epsilon_1} &= \frac{D_{t2}}{\epsilon_2} \end{aligned}\right\} \text{Tangintial}$$

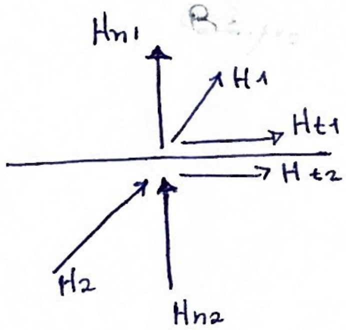
$$\left.\begin{aligned} D_{n1} - D_{n2} &= \rho_s \\ \epsilon_1 E_{n1} - \epsilon_2 E_{n2} &= \rho_s \end{aligned}\right\} \text{Normal}$$

$$\tan\theta_1 = \frac{\epsilon_1}{\epsilon_2} \tan\theta_2$$

• if perfect dielectric:- $\boxed{\sigma_2 = 0} \Rightarrow \boxed{\rho_s = 0}$

2. Magnetic Material.

$\boxed{\bullet \text{ magnetic field}}$ $\quad \bar{H} = H_t \bar{a}_t + H_n \bar{a}_n$



$$\left.\begin{aligned} \frac{B_{t1}}{\mu_1} - \frac{B_{t2}}{\mu_2} &= J_s \\ H_{t1} - H_{t2} &= J_s \\ \cdot\, n \times (H_1 - H_2) &= J_s \end{aligned}\right\} \text{Tangintial}$$

$$\left.\begin{aligned} B_{n1} - B_{n2} &= 0 \\ n \cdot (B_1 - B_2) &= 0 \end{aligned}\right\} \text{Normal.}$$

Q3] b) Test #2:- $\boxed{\text{Q 3-29 in the book}}$

• in region (1):-

$\vec{E}_1 = -5\,\bar{a}_x + 10\,\bar{a}_y + 15\,\bar{a}_z$. (V/m),

region (1) (air) $\quad \epsilon = \epsilon_0$

$z = 0$

Region (2) $\quad \epsilon = 5\epsilon_0$

(i) $\vec{D}$ and $\vec{E}$?

$\boxed{\rho_s = 0}$, $\boxed{\text{when } \rho_s \text{ isn't mentioned, put it equals to zero}}$.

$D_{n2} - D_{n1} = \rho_s$

$D_{n2} = D_{n1}$

$\epsilon_2 \bar{E}_{n2} = \epsilon_1 \bar{E}_{n1}$

$5\epsilon_0 \bar{E}_{n2} = \bar{E}_{n1}\, \epsilon_0 \Rightarrow \bar{E}_{n2} = \frac{E_{n1}}{5}\, \bar{a}_n$

$\bar{a}_n = \bar{a}_z$ (vector of the interface)

$\Rightarrow E_{n1} = \bar{E}_1 \cdot a_n = \bar{E}_1 \cdot \bar{a}_z = 15$

$\Rightarrow \boxed{\bar{E}_{n2} = \frac{15}{5} \bar{a}_z = 3\bar{a}_z}$

$\bar{E}_{t1} = \bar{E}_{t2}$, $\boxed{\bar{E}_{t1} = \bar{E}_1 - \bar{E}_{n1} = -5\bar{a}_x + 10\bar{a}_y = \bar{E}_{t2}}$

$\Rightarrow \boxed{\bar{E}_2 = -5\bar{a}_x + 10\bar{a}_y + 3\bar{a}_z}$

$\Rightarrow \boxed{\bar{D}_1 = \epsilon_0 \bar{E}_1 \quad , \quad \bar{D}_2 = 5\epsilon_0 \bar{E}_2}$

(iii) $\tan\theta_1 = \frac{\epsilon_1}{\epsilon_2} \tan\theta_2.$

$\tan\theta_2 = \frac{\epsilon_2}{\epsilon_1} \tan\theta_1.$

$\bar{a}_z \cdot \bar{E}_1 = |a_z||\bar{E}_1| \cos\theta$

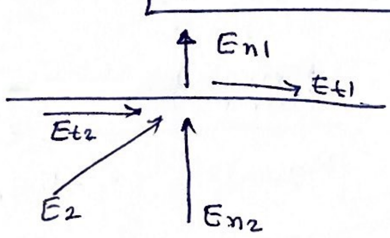
$\Rightarrow \cos\theta_1 = \frac{15}{|E_1|} = \frac{15}{\sqrt{5^2 + 10^2 + 15^2}}$

$\Rightarrow \theta_1 = 36.69^\circ \Rightarrow \tan\theta_1 = 0.7453$

$\Rightarrow \tan\theta_2 = \frac{5\cancel{\epsilon_0}}{\cancel{\epsilon_0}} \tan\theta_1 = 3.7267$

$\Rightarrow \boxed{\theta_2 = 74.97^\circ}$ or :- $\cos\theta_2 = \frac{E_{z2}}{|E_2|}$

(ii)



Q3-27] Problem's book.

$B_1 = 0.3\bar{a_x} + 0.4\bar{a_y} + 0.5\bar{a_z}$ (Wb/m²) , $\bar{a_n} = \bar{a_z}$, $\mu_1 = \mu_0$,

$\mu_2 = 4\mu_0$

(a) $\bar{a_z} \cdot \bar{B_1} = \boxed{0.5}$, $\Rightarrow B_{n1} = 0.5\,\bar{a_z}$

$B_{n1} = B_{n2} = 0.5\,\bar{a_z}$

$$\Rightarrow \frac{B_{t1}}{\mu_1} - \frac{B_{t2}}{\mu_2} = J_s = 0$$

$$\Rightarrow \frac{B_{t1}}{\mu_1} = \frac{B_{t2}}{\mu_2} \Rightarrow B_{t2} = \frac{\mu_2}{\mu_1} B_{t1}$$

$$\bar{B}_{t1} = \bar{B} - \bar{B}_{n1} = 0.3\bar{a_x} + 0.4\bar{a_y}$$

$$\Rightarrow \bar{B}_{t2} = \frac{4\mu_0}{\mu_0}\bar{B}_{t1} = 1.2\bar{a_x} + 1.6\bar{a_y}$$

$$\Rightarrow \bar{B}_2 = 1.2\bar{a_x} + 1.6\bar{a_y} + 0.5\bar{a_z}$$

$$\Rightarrow \bar{H}_2 = \frac{\bar{B}_2}{\mu_2} = \frac{0.3}{\mu_0}\bar{a_x} + \frac{0.4}{\mu_0}\bar{a_y} + \frac{0.125}{\mu_0}\bar{a_z}$$

$$\bar{H}_1 = \frac{\bar{B}_1}{\mu_1} = \frac{0.3}{\mu_0}\bar{a_x} + \frac{0.4}{\mu_0}\bar{a_y} + \frac{0.5}{\mu_0}\bar{a_z}$$

(b) To find $\theta_1 \Rightarrow$ $a_n \cdot H_1 = |a_n|\,|H_1| \cos\theta_1$

$$a_z \cdot \bar{H}_1 = |a_z|\,|H_1| \cos\theta_1$$

$$\Rightarrow \cos\theta_1 = \frac{H_{z1}}{|H_1|} = \frac{0.5}{\sqrt{(0.3)^2 + (0.4)^2 + (0.5)^2}}$$

$$\Rightarrow \boxed{\theta_1 = 45^\circ} \Rightarrow \tan\theta_1 = 1$$

$$\Rightarrow \tan\theta_2 = \frac{\mu_2}{\mu_1}\tan\theta_1 = \frac{4\mu_0}{\mu_0}\tan\theta_1 = \boxed{4}$$

$$\Rightarrow \boxed{\theta_2 = 75.96 = 76^\circ}$$